1-

	1	2	3	4
FC I	$10,000	$12,000	$14,000	$16,000
operating cost	$3,000	$2,800	$2,350	$2,100

ROII > 15

* Compare [1] & [2]

$$ROII = \frac{3,000 - 2,800}{12,000 - 10,000} * 100 = 10\% < 15\%$$

[2] is cancelled

* Compare [1] & [3]

$$ROII = \frac{3,000 - 2,350}{14,000 - 10,000} * 100 = 16.25\% > 15\%$$

[1] is Cancelled

* Compare [3] & [4]

$$ROII = \frac{2,350 - 2,100}{16,000 - 14,000} * 100 = 12.5\% < 15\%$$

∴ [3] is The best choise.

Cost of G : $0.3/1,000,000 Btu

ROII > 15 %

300 days/yr = 300 * 24 hrs/yr

	1"	2"	3"	4"
$\frac{Btu}{hr}$ saved	300,000	350,000	370,000	380,000
$\frac{Btu}{yr}$ saved	$2.16 * 10^9$	$2.52 * 10^9$	$2.664 * 10^9$	$2.736 * 10^9$
Cost of Btu's Saved	$648	$756	$799.2	$820.8
→ Cost of ins.	$1,200	$1,600	$1,800	$1,870
Annual fixed ($) charges	10%	10%	10%	10%
Annual fixed ($) charges	$120	$160	$180	$187
→ Total Saving	$528	$596	$619.2	$633.8

(i) Compare ① & ② :

$$ROII = \frac{596 - 528}{1600 - 1200} * 100 = 17\% > 15\%$$

∴ 2" is better than 1"

(ii) Compare ② & ③

$$ROII = \frac{618.2 - 596}{1800 - 1600} * 100 = 11.6\% < 15\%$$

∴ 2" is better than 3"

(iii) Compare ② & ④

$$ROII = \frac{633.8 - 596}{1870 - 1600} * 100 = 14\% < 15\%$$

∴ 2" is the best choise

	Boiler & steam turbine	gas turbine
Initial investment	$ 600,000	$ 400,000
Fuel Costs /yr	16,000	23,000
Maintenance /yr	12,000	15,000
Insurance & tax /yr	18,000	12,000
Service life	20	10
Salvage value	0	0
depreciation /yr	30,000	40,000
Manufact. Cost/yr	76,000	90,000

$$ROI = \frac{90,000 - 76,000}{600,000 - 400,000} * 100 = 7\% < 12\%$$

∴ Gas turbine is better

4-

old unit

$V_0 = \$40,000$

$V_S = \$1,000$

$n = 15$ years

$$d = \frac{40,000 - 1,000}{15}$$

$= \$2,600/yr \rightarrow$ old

Cost now = $ 5,000

$$d = \frac{5,000 - 1000}{10} = \$400$$

→ now → life region of comparison

new unit

$V_0 = \$70,000$

increase in income = $ 5000 /yr

Labour saving = $ 7,000 /yr

additional taxes & Ins = $ 1,000/yr

$n = 12$

$V_S = \$1,000 \rightarrow d = \frac{70,000 - 1,000}{12}$

$d = \$5,750/yr$

* annual saving = $ 5,000 + 7,000 − 1,000 − (5,750 − 400)

= $ 5,650

* additional investment = 70,000 − 5,000 = $65,000

$$ROI = \frac{5650}{65,000} * 100 = 8.7\% < 15\% \rightarrow$$ don't replace

old

$V_0 = \$600$

$V_n = \$100$

$n = 5$ yrs

$$d = \frac{600-100}{5}$$

$= \$100/yr$

new

$V_0 = \$6000$

$n = 10$ yrs

$V_n = 0$

Labour & mant reduced $= \$1{,}000$

annual expenses increased $= \$100$

$$d = \frac{6000-0}{10} = \$600/yr$$

→ annual savings $= 1000 - 1000 + 100 - 600 = \$400/yr$

additional investment $= \$6{,}000 - 600 = \$5{,}400$

$$\therefore ROII = \frac{400}{5400} \times 100 = 7.4\ \%$$

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c-

$V_0 = \$500{,}000 \longrightarrow i = 0.011$

$V_{goods} = \$400{,}000 \longrightarrow i = 0.0095$

→ sprinkling system → $i_1 = 0.0825$

$i_2 = 0.07125$

Cost of system $= \$20{,}000$

additional costs $= \$300/yr$

$n = 20$ years

→ depreciation $= \frac{20{,}000 - 0}{20} = \$1{,}000$

∴ additional investment $= \$20{,}000$

old annual insurance $= 0.011 \times 500{,}000 + 0.0095 \times 400{,}000 = \$9{,}300/yr$

∴ Savings in insurance $= \frac{1}{4} \times 9{,}300 = \$2{,}325/yr$

∴ annual savings $= 2{,}325 - 1{,}000 - 300 = \$1025$

$$\therefore ROII = \frac{1025}{20{,}000} \times 100 = 5.125\ \% < 8\ \%$$

Batch system

$$NPW = -20{,}000 + \frac{5600}{(1+i)^1} + \frac{5600}{(1+i)^2} + \frac{5600}{(1+i)^3} + \text{———} + \frac{5600}{(1+i)^{15}}$$

check for $i = 0.25$ ⟶ $NPW \cong 0$ ⟶ ~ it's true value of DCFRR

Cont. system

$$NPW: -30{,}000 + \frac{7650}{(1+i)^1} + \frac{7650}{(1+i)^2} \text{ ———— } + \frac{7650}{(1+i)^{16}}$$

check for $i = 0.22$ ⟶ $NPW \cong 0$ ⟶ ~ it's true value of DCFRR

⟶ check NPW

@ $i = 10\%$ ⟶ $NPW)_{cont} = \$17{,}006 > \$17{,}000$ } True

$NPW)_{batch} = \$14{,}409 = \$14{,}400$

8-

Large pump:

$$NPW = -1600 + \frac{20{,}000}{1+i} \rightarrow @\ NPW = 0 \quad i = 11.5\ \$ = 1150\ \%$$

old pump

$$NPW = \frac{10{,}000}{1+i} + \frac{10{,}000}{(1+i)^2} \rightarrow \text{no way} \quad NPW = 0$$

at $i = 10\%$

Large pump $NPW = \$16{,}580$

old pump $NPW = \$17355$

In $1600 additional capital

$10,000 savings in yr 1

-$10,000 " " " 2

$$-1600 + \frac{10000}{1+i} - \frac{10000}{(1+i)^2} = 0 \longrightarrow i = 25\ \% > 10\% \longrightarrow \text{larger pump is better}$$

7. Contd

$ 10,000 additional capital

$ 2,050 savings/yr

$$\therefore \quad -10{,}000 + 2050\left[\frac{1}{(1+i)} + \frac{1}{(1+i)^2} + \frac{1}{(1+i)^3} + \cdots\cdots \frac{1}{(1+i)^{15}}\right] = 0$$

$i = 15.75\ \% > 10\ \%$ Cont. system is better

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9. metal value = $0.2/lb

Feed = 10^6 lb metal/yr

n = 5 years

	2	3	4	5
Capital inv.	$ 25,000	$ 35,000	$ 44,000	$ 52,000
Recovery %	75 %	95 %	98 %	99.5 %
metal recovered (lb)/yr	750,000	950,000	980,000	995,000
value of metal $/yr recovered	$ 150,000	$ 190,000	$ 196,000	$ 199,000
depreciation	$ 5,000	$ 7,000	$ 8,800	$ 10,400
annual op. cost	$ 6,000	$ 8,000	$ 10,000	$ 11,000
Total annual expenses	$ 11,000	$ 15,000	$ 18,800	$ 21,400
Total savings	$ 139,000	$ 175,000	$ 177,200	$ 177,600

Compare 2 Stages & 3 Stages

$$ROI = \frac{175{,}000 - 139{,}000}{35{,}000 - 25{,}000} * 100 = 360\ \%$$

∴ 3 stages is better

Compare ③ & ④ stages

$$ROI = \frac{177{,}200 - 175{,}00}{44{,}000 - 35{,}000} * 100 = 24.4\ \% > 15\ \%$$

4 stages is better

Compare ④ & ⑤ stages

$$ROII = \frac{177{,}600 - 177{,}200}{52{,}000 - 44{,}000} \times 100 = 5\% < 15\%$$

∴ 4 stages is best choise

Feed = 450,000 lb soln/day 5% NaOH ⟶ 40% NaOH

	1	2	3	4	5
→ Fixed Cost	$ 18,000	$ 36,000	$ 54,000	$ 72,000	$ 90,000
depreciation/yr	$ 1,200	$ 2,400	$ 3,600	$ 4,800	$ 6,000
Fixed charge/yr (%) =	20%	20%	20%	20%	20%
Fixed charge/yr ($/yr)	$ 3,600	$ 7,200	$ 10,800	$ 14,400	$ 18,000
steam cost	$ 78,750	$ 39,375	$ 26,250	$ 19687.5	$ 15,750
→ annual Manuf cost	$ 82,350	$ 46,575	$ 37,050	$ 34087.5	$ 33750

mass of water evapn / lb st = 0.9 X

mass of water evap.

* initial mass of NaOH = 450,000 * 0.05
= 22,500 lb/day
* final mass of soln = 22,500 * 100/40
= 56.25 lb/day
* mass of water evap /day = 427,500 - 33,750
= 393,750 lb/day
* mass of steam needed = 393,750/0.9X
= 437,500/X lb/day
* Cost of steam = 437,500/X * 0.6/1000
= $ 262.5/X /day
= $ 78,750/yr/X

* Compare ① & ② effects

$$ROII = \frac{82{,}350 - 46575}{36{,}000 - 18{,}000} \times 100 = 198.75\% > 15\%$$

* Compare ② & ③ effects

$$ROII = \frac{46{,}575 - 37{,}050}{54000 - 36000} \times 100 = 52.92\% > 15\%$$

* Compare ③ & ④ effects

$$ROII = \frac{37{,}050 - 34{,}087.5}{72{,}000 - 54{,}000} \times 100 = 16.46\% > 15\%$$

* Compare ④ & ⑤ effects

$$ROII = \frac{34{,}087.5 - 33{,}750}{90{,}000 - 72{,}000} \times 100 = 1.875\% < 15\%$$

∴ 4 effects is optimum one